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Description

This invention relates to bar code scanners and more particularly to a decoding method for selecting a bar-coded candidate from several possible candidates.

One of the more significant changes in the supermarket industry in recent years has been the general acceptance of product-identifying labels encoded using a standard bar code format. Such labels can be automatically read at a checkout stand by an optical scanning component of a point-of-sale system. Decoded label information can be used for a number of purposes, including look-up of item prices stored in the memory, performance of inventory control operations, tracking of monitoring of sales of particular items and preparation of descriptive customer receipt tapes.

Various versions of the code are in use in different countries around the world. In a given country, a UPC (Universal Product Code) format, an EAN (European Article Number) format or a JAN (Japanese Article Number) format may be in use. While the formats may differ from each other in details, all use the same basic encoding system wherein a data character is represented by a combination of two bars alternating with two spaces.

The majority (0, 3, 4, 5, 6 and 9) of decimal characters can be decoded using certain bar-space pair measurements taken within the character. There are, however, certain decimal characters (1, 2, 7 and 8) which cannot be uniquely identified by the bar-space pair measurements alone. The bar-space pair measurements are sufficient to identify each of the two subsets (1, 7 and 2, 8) into which these characters are grouped. The final identification of a character within one of the subsets requires an additional bar width measurement. Such a method is disclosed in FR—A—2387478.

The bar code representations of the digits 1, 2, 7, 8 are often referred to as ambiguous characters since they cannot be fully decoded with bar-space pair measurements alone. The bar code representations of the remaining digits, which can be decoded with bar-space pair measurements, are sometimes referred to as non-ambiguous characters.

If the UPC labels actually printed and in use always conformed strictly to all stated standards regarding bar widths, reflectance, etc., if the scanners which read those labels always operated optimally, and if labels being scanned were always optimally oriented relative to the scanner, then multiple scans of a label would probably always result in the same label candidate. However, because labels are printed, handled and scanned under real (rather than optimal) conditions, it is not unusual for multiple scans of a single label to result in two or more different label candidates. For example, a five digit label "47736" might be read as "42136", "48136", "42736" and "48736" during four scans due to the difficulty in distinguishing between ambiguous characters.

The problem which then arises is how to select the most likely of several different candidates for further processing which will finally determine whether the selected candidate is a valid one. The further processing may take the form of a modulo check. One of the characters in the label is generated when the label is created by combining the remaining characters in the label in accordacne with a known algorithm. To determine whether the label has been correctly read by a scanner, those characters are recombined after decoding using the same algorithm to determine whether the calculated modulo character matches the character actually detected on the label. If the calculated and detected modulo values don't match, it is assumed that the label candidate is an invalid one.

It would, of course, be possible to perform a modulo check on every single different label candidate to deteermine which of the candidates would survive such a check. The obvious drawback to this approach is that it would require an unreasonable amount of processor time and an unreasonable amount of buffer storage. A requirement for added buffer storage affects the cost of the system. A requirement for added processor time can adversely affect system response time. If a more powerful processor is used to achieve an acceptable level of system response, the cost of the system is increased.

Another known technique is to fully decode every possible label candidate before attempting to select a particular candidate for modulo checking. The label candidate that appears most frequently is then selected for modulo checking. A method for selecting the label candidate is described in IBM Technical Disclosure Bulletin, Volume 17, No. 7, December 1974, pages 2080—2081.

While this technique is better than the more conservative technique described above, it still has some drawbacks. While this technique may require less time to carry out in practice since the most frequently occurring candidate is probably the correct candidate, a considerable amount of processor time is still required to decode all of the ambiguous characters in all of the potential candidates.

Disclosure of invention

According to the present invention there is provided a decoding method for more effectively selecting the best label candidate from among a plurality of label candidates resulting from several scans of the same label.

The label is a multi-character label having one or more ambiguous positions, each of which is occupied by a character included in the set of characters which is ambiguously decoded during each of multiple scans of the label. The decoding method includes the steps of deriving and storing a preliminary label value following each scan. The preliminary label value has a common set-identifying character assigned to any ambiguous position. A tentative ambiguity-resolving value is derived and stored for each ambiguous position. The tentative values for each ambiguous position are combined to select a final character value for that ambiguous position as a function of a number of times a specific character has been tentatively identified as occupying that position.

The advantage of the corroboration technique is that no effort is made to forward a label candidate for further processing until ambiguities between ambiguous characters are resolved by the majority vote technique. As a result, there will be a savings in processor time.

The details of a preferred implementation of the invention may be more readily ascertained from the following description when read in conjunction with the accompanying drawings wherein:

Figure 1 is a generalized block diagram of a bar code scanning system within which the present invention may be used.

Figure 2 shows the general format of one commonly-used type of label employing bar code characters.

Figures 3 and 4 represent the two forms of the bar coded representation digit "4" as that character would appear both to the left (odd) and to the right (even) of the center character in a label.

Figure 5 depicts a UPC character and is labelled to show certain measurements used in the decoding of characters.

Figure 6 is a general flow chart of a decoding method employing the present invention, and

Figures 7 through 10, taken together, are a more detailed flow chart of the decoding method represented generally in Figure 6.

Referring to Figure 1, a checkout stand is represented generally by a surface 10 having a transparent scanner window 12. As a grocery item 14 is moved over window 12, a bar coded label 16 on the product surface is swept one or more times by a light beam 18 which originates below the checkout stand surface in an optical subsystem 20. Light reflected from the label 16 impinges on a photosensitive element in the optical subsystem 20. Reflected light, the level of which varies as a function of the reflectance of the particular point on the package being scanned, is converted into a roughly sinusoidal electrical signal which is applied to threshold and shaping circuits 22. A function of the circuits 22 is to convert the roughly sinusoidal signal to a square wave pulse train in which the duration of each pulse bears a temporal relation to a particular light or dark area being traversed by the beam 18.

In almost all instances, a bar-coded label is surrounded by printed matter, graphics, pictorial material, etc., which may produce code-like reflections. Candidate select logic circuits 24 serve to "find" the actual label signals among the extraneous and meaningless signals produced upon scanning of printed matter, etc. When one or more label candidates has been found, those candidates are transferred to a candidate decoding processor 26, the functions of which are to select the most likely label candidate from a possible plurality of different candidates and to generate numeric representations of the selected candidates. The finally selected decoded label is then passed on to a point-of-sale terminal 28 or possibly a store controller to permit price lookup operations, inventory control operations, and perhaps other functions, to be performed.

Referring to Figure 2, a widely used type of UPC label includes guard characters 30 at the left and right margins of the label. The data characters in the label are divided by a center character 32 into a left (odd) set of data characters and a right (even) set of data characters. The difference between the data characters to the left of the center character 32 and the data characters to the right of the center character 32 and the meanings of the terms "odd" and "even" are explained with reference to Figures 3 and 4.

Figure 3 is a UPC representation of the digit "4" as it would appear in the bank of the characters to the left of the center character 32. Like all data characters, the "4" character is considered to be seven modules long with each bar or space being one of more modules in width. The odd "4" character consists of a single module space 34, a single module bar 36, a three module space 38, and a two module bar 40. This particular character has at least two things in common with all of the characters appearing to the left of the center character 32. First, every character begins with a space and ends with a bar. Second, the combined width of the bars 36 and 40 is an odd number of modules; in this case, three.

Referring to Figure 4, when the UPC representation of the digit "4" appears to the right of the center character, the coded character is the binary complement or "negative image" of the left or odd "4". That is, the encoded representation has a bar in each module occupied by a space in the odd "4" and a space in each module occupied by a bar in the odd "4". Characters appearing to the right of center are referred to as even characters, since the bars occupy an even number of modules; in this case, four.

The following table is an encodation of the digits 0—9 as those digits would be represented to the left and right of the center character on a UPC label. A "0" represents a white bar or space while a "1" represents a black or dark bar.

Double or wider bars and spaces are represented by two or more adjacent identical binary characters. An inspection of the table shows that all "left" characters exhibit odd parity; that is, the combined width of the bars in each character is equal to either three or five modules. In contrast, all "right" characters exhibit even parity; i.e., the combined width of the bars in a character is always two or four modules.

TABLE 1

Digits	Left (odd) characters	Right (even) characters
0	0001101	1110010
1	0011001	1100110
2	0010011	1101100
3	0111101	1000010
4	0100011	1011100
5	0110001	1001110
6	0101111	1010000
7	0111011	1000100
8	0110111	1001000
8	0001011	1110100

A label of the type shown in Figure 2 is found or framed and then decoded 1/2 at a time. That is, the candidate select logic will identify as a possible label any stream of data characters bounded by a center character and a guard character. The actual decoding of any candidate begins at the center character and proceeds one character at a time toward the guard characters. The left and right label halves are combined only after decoding.

Within a given label, all data characters have the same physical width. From one label to the next, the absolute width of the data characters may vary over roughly two-to-one range. For that reason, a UPC label is decoded as much as possible using relative width measurements rather than absolute width measurements. Referring to Figure 5, three of the width measurements used in the decoding process are defined there. Measurement T1 represents the combined width of the first bar-space pair in the character in the direction of decoding. Measurement T2 is equal to the combined width of the first space-bar pair in the direction of decoding. The measurement TR represents the total width of the two bars and two spaces which make up the character. A fourth measurement, not illustrated, which may be needed to decode the "ambiquous" characters 1, 2, 7, 8 is ΣTB which is equal to the combined widths of the two black bars in the particular data character. In practice, all of these measurements are expressed as the number of constant frequency pulses or counts produced by a high speed oscillator as the relevant region is traversed by the scanning beam. For example, assume the system uses a 7 MHz oscillator and that the scanning beam requires 30 microseconds to traverse an entire character. Under those conditions, TR would equal 30×10^{-6} sec, 7×10^{6} counts/sec or 210 counts.

The majority of UPC representations of digits (0, 3, 4, 5, 6 and 9) can be decoded using the T1, T2 and TR measurements. These measurements are normalized within the decoding process into N1 and N2 values in accordance with the following equations.

$$N1=\frac{7T1}{TR} \qquad (1)$$

$$N2=\frac{7T2}{TR} \qquad (2)$$

Since each data character is considered to be seven modules wide, the N1 and N2 values are actually normalized representations of the T1 and T2 mesaurements, respectively.

TABLE 2

Left (odd)	N1	N2	Right (even)	N1	N2
0	2	3	0	5	3
1	3	4	1	4	4
2	4	3	2	3	3
3	2	5	3	5	5
4	5	4	4	2	4
5	4	5	5	3	5
6	5	2	6	2	2
7	3	4	7	4	4
8	4	3	8	3	3
9	3	2	9	4	2

The values of N1 and N2 for the odd and even UPC representation of the digits are shown in Table 2. The various unique combinations of N1 and N2 values which result from the application of equations 1 and 2 are sufficient to fully identify the six non-ambiguous digits 0, 3, 4, 5, 6 and 9. The table shows, however, that 1 cannot be distinguished from 7 in either the odd or the even set of characters since both have the same N1 and N2 values. Similarly, 2 cannot be distinguished from 8 on the basis of N1 and N2 values alone.

To distinguish a 1 from a 7 or a 2 from an 8, an additional measurement is required. The additional measurement is the bar width measurement ΣTB, representing the combined width of the two bars in the data character. In the decoding process, the ΣTB is normalized to yield an NB value in accordance with the formula:

$$NB=\frac{7\Sigma TB}{TR} \qquad (3)$$

The combined widths of the bars of the two possible characters in a subset (for example, odd 1, odd 7) are always different and can be used to distinguish one of the subset characters from the other. For example, NB for odd 1 is equal to three while NB for odd 7 is equal to five.

The idealized, normalized NB values for the ambiguous characters 1, 2, 8, 8 are listed below in Table 3. These NB values are needed to fully decode those characters.

TABLE 3

Left (odd)	NB	Right (even)	NB
1	3	1	4
2	3	2	4
7	5	7	2
8	5	8	2

The N1, N2 values are sufficient to determine whether an ambiguous character is in the odd or the even set of ambiguous characters. Similarly, the N1, N2 values indicate whether the ambiguous character is in the 1, 7 subset or the 2, 8 subset. To determine at least tentatively which of the two possible characters has been read, the N1, N2, NB values are used in one of the two following formulas, depending on whether the character is in the odd or even set:

$$\frac{2NB}{1+N1+N2} \text{(for odd characters)} \quad (4)$$

$$\frac{2(7-NB)}{1+(7-N1)+N2} \text{(for even characters)} \quad (5)$$

For odd characters, the results of formula 4 will always be less than 1 for a 1 or a 2 and greater than or equal to 1 for a 7 or an 8. Similarly, for even characters, the results of formula 5 will always be less than 1 for a 1 or a 2 and greater than or equal to 1 for a 7 or an 8. This is summarized in Table 4 below.

TABLE 4

Identified subset	Value of formula (4), (5)	
	<1	≥1
ODD 1, 7	ODD 1	ODD 7
ODD 2, 8	ODD 2	ODD 8
EVEN 1, 7	EVEN 1	EVEN 7
EVEN 2, 8	EVEN 2	EVEN 8

For reasons which will be explained in more detail below, algebraic values of equal magnitude and opposite polarity are assigned depending on whether the selected formula produces a result less than 1 or greater than or equal to 1. For example, if either formula 4 of formula 5 produces a result less than 1, an arbitrary value of −1 is assigned. If either formula produces a result greater than or equal to 1, an algebraic value of +1 is assigned. The actual results of the computations are referred to as D. The algebraic values assigned as a function of the results are referred to as D′.

In the decoding method to be described below, the term "character identifiers" is frequently used. For a non-ambiguous character, the character identifiers are the N1, N2 values defined above. For ambiguous characters, the identifiers are N1, N2 and D′, also defined above.

Referring now to Figure 6, which is a block diagram showing the decoding method in very general terms, the bar coded label to be decoded must obviously be scanned (block 602) before decoding can be performed. When all possible label candidates are selected (block 604) from the scan results, one label candidate is entered (block 606). The identifiers for each of the characters in that candidate are computed (block 608) and then compared on a character-by-character basis with stored identifiers (block 610) for a previously entered label candidate, if any. If not all of the character identifiers for the entered candidate match corresponding identifiers for the stored candidate (block 612), a check is made (block 614) to determine whether another buffer is yet to be checked from the array of candidate buffers. If all of the buffers have been checked and no match has been found, the currently entered candidate is discarded. If another buffer has yet to be checked, then it must be determined (block 618) whether that buffer is empty. If the buffer is not empty, meaning a previously selected candidate is stored therein, the program returns to block 610 and the identifiers for the entered candidate are compared with the identifiers for the candidate in the newly selected buffer. If, however, the check of block 618 shows the newly selected buffer to be empty, the identifiers for the entered candidate are written into the previously empty buffer (block 620).

If the check made at block 612 indicates that the identifiers for all characters in the entered candidate match the identifiers for all characters in the candidate stored in the selected buffer, the 1—7, 2—8 identifier or "D" value for each ambiguous character is updated in the selected buffer (block 622). A check is then made (block 624) to determine whether any more candidates are to be entered. The program is also re-entered at block 624 after a candidate has been discarded (block 616) or after a candidate has been written into a previously empty buffer (block 620).

If there are more candidates to be processed, the program loops back to block 606 and a new candidate is entered and processed. If the check made at block 624 indicates that there are no additional candidates to be processed, a "plurality" vote is taken (block 626) to determine which candidate appeared the greatest number of times. This candidate is selected as the final buffer candidate. It should be noted the buffer candidate is selected for full decoding without attempting to distinguish between a 1 and a 7 or a 2 and an 8. All non-ambiguous characters are decoded using N1, N2 values and choices between a 1 and a 7 or a 2 and an 8 in the final candidate are made on a majority vote basis (block 628). The fully decoded final candidate is transferred within the system for modulo checking.

The decoding method is described in much greater detail in figures 7, 8, 9 and 10 which, taken together, constitute a detailed flow diagram of the entire technique. Referring to Figure 7, when the label has been scanned (block 702) and all candidates have been selected and stored as a series of pulse width counts (block 704), the number of buffers to be used for decoding the particular type of scanned label is initialized at a quantity K (block 706). The character count or number of characters in the label to be decoded is initialized at a quantity M (block 708). A buffer pointer b is then set to 1 (block 710) to point to the first of the available buffers. After a candidate is entered (block 712), an equal flag is set (block 714). As will be explained in more detail later, the value of the equal flat at the end of a comparison phase is an indication whether or not an entered candidate matches a previously entered candidate.

A character pointer m is then set to 1 (block 716) to point to the first character to be decoded in the entered label. The values N1, N2 are computed (block 718) in accordance with the equations (1) and (2). The computed N1, N2 values are used (block 720) to obtain a parity value T from a lookup table which is the electronic equivalent of Table 2 above. The parity value obtained is stored (block 722) in a temporary type register.

A check must then be made (block 724) as to whether the computed N1, N2 values have identified an ambiguous character. If a 1—7 or a 2—8 is indicated by the N1, N2 values, then either formula 4 or formula 5 must be called up (block 726) as a function of the parity of the decoded character. The value of D is computed (block 728). If D is less than 1, D' is set to −1. If D is greater than or equal to 1, a +1 value is assigned to D'.

If the check at block 724 resulted in identification of, a non-ambiguous character, there is no need for a computation of a D value. The program would skip blocks 726 and 728 and go directly to a block 730 where a check is made as to whether or not the currently entered candidate is the first candidate to be processed. If it is the first candidate, the character being decoded obviously cannot be compared with any corresponding character in a previously entered candidate. The program skips a number of steps which will be discussed below and goes directly to an operation 806 in which the computed identifiers for the character are stored in a temporary register. The character pointer m is incremented (block 808) and a check is made as to whether the value of m is greater than M, which would indicate that all of the characters in the entered candidate have been processed. If the check in block 810 indicates there are characters in the label yet to be processed, the program loops back to operation 718 at which the values of N1, N2 are computed for the next character in the label. If, however, the check at block 810 indicated that all of the characters have been processed, another check 812 must then be made as to whether the equal flag is set. Since the first candidate to be entered can't be compared to any other candidate, the equal flag will always be reset for the first candidate.

Assuming the equal flag is set, a tag value (which would be 0 for the first candidate) is incremented (block 902) in the selected buffer b. The character identifiers for all of the characters in the candidate are written into buffer b (block 904). For non-ambiguous characters, the identifiers are N1, N2. Ambiguous characters are identified by N1, N2 and ΣD' value which is obtained in a manner to be described in more detail later.

After the character identifiers for the first label candidate are written into the buffer b, a check is made (block 920) as to whether there are any more candidates to be processed. If there are, the program is resumed at the entry of block 710. The buffer pointer is again set to the first buffer and the next candidate is entered.

The process of computing character identifiers is repeated for the second candidate. When the program reaches block 730, however, the check made there will indicate that the currently entered candidate is not the first candidate. At this point, the stored identifiers for each character under consideration are retrieved from storage in buffer b (block 732) and comparisons are performed (block 734 and 736) between the stored and computed values of N1 and N2, respectively. If any mismatch is found in either of these checks, the equal flag is reset (block 738) and the program proceeds to decision block 802. If the stored and computed N values are equal, the program goes directly to block 802 where a check is made as to whether the character is an ambiguous one. If it is, a stored value of ΣD' is altered by the magnitude of the computed quantity D' (block 804). If the character is not an ambiguous character, operation 804 is bypassed. The computed identifiers for the character under consideration are stored in the temporary register (block 806) and character pointer m is incremented to permit the same set of comparisons to be made for the next character in the currently entered label candidate. When all of the characters in the entered candidate have been compared to corresponding characters in the previously entered and stored candidate, a check is made (block 812) to determine whether the equal flag remains set. If the equal flag is set, indicating that the entered candidate matches the stored candidate, the tag value in the accessed buffer (block 902) is incremented to indicate that the same label candidate has been found a number of times equal to the tag value.

At this point, no effort is made to distinguish between a 1 and a 7 or a 2 and an 8. The final choice between each of the two possible characters is made at a later point as a function of ΣD' for the character position in question. The value N1, N2, T and any ΣD' values for the entire label candidate are then loaded into the accessed buffer (block 904). Since the N1, N2 and T values should match those already in the buffer, there will be no change in buffer contents for these values. Any ΣID' values which are loaded into the buffer are necessarily different from the ΣD' values previously stored there. Once the write operation is completed, a check (block 920) is made as to whether there are any more candidates to be processed. If there are, the program loops back to block 710. The next candidate is entered and is compared to the candidate previously stored in buffer 1 on a character-by-character basis.

If, however, the check at block 812 had indicated that the equal flag was reset due to a mismatch in any character position, the tag value in buffer b (block 910) is read. If the tag value is 0, indicating that the buffer is empty, the program branches to block 902 and causes the newly entered candidate to be written into the empty buffer. If the tag value in the accessed buffer is not equal to 0, indicating that there is already a dissimilar candidate stored in that buffer, the buffer pointer is incremented (block 914) and a check is made (block 916) as to whether the buffer pointer is still pointing at a buffer within the acceptable range. If the buffer pointer value is greater than the number of buffers allocated for this purpose, the candidate is discarded (block 918) and the check 920 is made as to whether there are any more candidates to be processed.

If the incremented buffer pointer indicates that there is another buffer in the set which either may be empty or may contain a label candidate to be compared with the currently entered candidate, the program returns to block 714. The equal flag is set and the characters in the entered candidate are compared one at a time to the characters in the newly accessed buffer.

This process is repeated with each newly entered candidate being compared to the candidates previously stored in the buffers until:

(1) a match is found between the entered candidate and a previously stored candidate, in which case the tag value and the ΣD' values for any ambiguous characters are altered in the accessed buffer;

(2) no match can be found between the entered candidate and any of the candidates stored in the buffers but an empty buffer is available, in which case the entered candidate is written into the previously empty buffer; or

(3) no match can be found between the entered candidate and any previously stored candidates and no buffers are available, in which case the entered candidate is discarded.

Once the check 920 indicates that no more candidates are available for processing, the program enters a final decoding phase. This phase of the program begins at block 1002 where the buffer pointer b is set to point to the buffer in the array having the maximum tag value; that is, the buffer containing the partially decoded candidate which appeared the greatest number of times. The character pointer is set to point to the first character in that buffer (block 1004). The values of N1, N2 and any ΣD' for that character are read from the buffer (block 1006). The N1 and N2 values are used (block 1008) to decode to one of 16 possible characters. The 16 characters consist of odd 1—7 (treated as a single character), odd 2—8 (treated as a single character), odd 3, odd 4, odd 5, odd 9, odd 0, even 1—7 (treated as a single character), even 2—8 (treated as a single character), even 3, even 4, even 5, even 6, even 9, and even 0.

Once the partial decode has been performed, a check (block 1010) is made to find out whether the N1, N2 values indicates an ambiguous character. If a non-ambiguous character is indicated, the program branches to a write operation (block 1022) in which the decoded character is written into a label buffer.

If check 1010 reveals an ambiguous character, a second check (block 1012) is made to determine whether the value of ΣD' is equal to 0. If ΣD' is equal to 0, indicating that an ambiguous character was tentatively identified as one of two possible characters the same number of times that it was identified as the other of the two possible characters, the candidate is discarded (block 1014) and a "bad scan flag" is set (block 1015) to allow the operator to be notified that the item should be rescanned. The program loops to its entry point at block 702 under these conditions.

If block 1012 indicates that the value of ΣD' is equal to something other than 0, then a decision is made (block 1016) as to whether ΣD' is greater than or less than 0. If ΣD' is less than 0, the ambiguous character is either a 1 or a 2 (block 1018). If ΣD' is greater than 0, the ambiguous character is taken to be a 7 or an 8 (block 1020). The process of selecting one of the other of the ambiguous characters amounts to a majority vote technique since the algebraic sign of ΣD' is clearly a function of which of the two possible choices occurred more often.

When a final choice is made between one of the two possible ambiguous characters, that decoded character is written into the label buffer (block 1022) and the character pointer is incremented (block 1024). If the character pointer is still within the permissible range of characters (block 1026) the decode loop is re-entered at block 1006 to fully decode the next character. When all of the characters in the label have been fully decoded, the now fully decoded final candidate is forwarded within the system for modulo checking.

Conceptually, both majority vote decisions and a plurality vote decision are made in finally choosing the label candidate on which a modulo check is performed. The plurality vote is used to choose that partially decoded candidate which appeared more frequently than any other complete candidate. The majority vote is used to choose one of two possible ambiguous characters in a given character position as a function of which of those two characters appeared most frequently during preliminary decoding.

Claims

1. For use in a label scanning system of the type wherein a plurality of multicharacter label candidates may be generated as a result of multiple scans of a label, a decoding method wherein a set of up to three indicators (N1, N2, ΣD') is derived

and stored for each character segment in each label candidate, two (N1, N2) of said three indicators being capable of identifying either individual characters or subsets of characters, said third indicator (ΣD') being capable of identifying a particular character within a given subset; further characterized in that it comprises the following steps:

a) comparing the first two indicators (N1, N2) for each character segment in a given candidate to the corresponding indicators for a corresponding character segment in at least one other label candidate to determine whether the label candidates have matching characters or matching subsets of characters;

b) accumulating the third indicators (ΣD') for corresponding character segments until all label candidates have been compared; and

c) selecting a particular character for each character segment identified as being occupied by a subset as a function of the accumulated third indicator values for that segment.

2. A decoding method as recited in claim 1 characterized in that the label to be decoded consists of a plurality of bar-coded character segments, each consisting of an equal number of bars and spaces and wherein said first and second indicators are derived by forming ratios of the combined widths of successive bar-space pairs to the total character segment width.

3. A decoding method as recited in claim 2 characterized in that said third indicator is derived as a function of the combined bar widths in a character segment and of the magnitudes of the first and second indicators.

4. A decoding method as recited in claim 3, characterized in that said first indicator N1 and said second indicator are derived by the equqtions:

$$N1 = \frac{7T1}{TR} \qquad N2 = \frac{7T2}{TR}$$

where:

T1 is the combined width of the first bar-space pair in the character segment,

T2 is the combined width of the first space-bar pair in the character segment, and

TR is the combined width of the two bars and spaces which comprise the character segment.

5. A decoding method as recited in claim 4 characterized in that individual characters or subsets of characters are classified as odd or even depending on the derived values N1 and N2 and wherein the third indicator is established as

$$\frac{2NB}{1+N1+N2}$$

for odd characters or

$$\frac{2(7-NB)}{1+(7-N1)+N2}$$

for even characters

where NB is the total bar width of the character segment.

6. A decoding method as recited in claim 5 characterized in that an absolute value D' having one algebraic sign is assigned to the third indicator where that indicator value is equal to or greater than a given threshold value while the same absolute value D' having the opposite algebraic sign is assigned to the third indicator where that indicator value is less than the given threshold value.

7. A decoding method as recited in claim 6 characterized in that the third indicator is accumulated by summing the algebraic values D' with a positive result representing one of two possible characters in a subset and a negative result representing the other of the two possible characters.

8. A decoding method as recited in any one of claims 1—7 characterized in that it includes the additional steps of storing a tag value for each label candidate representing the number of times that candidate has been decoded and selecting the label candidate having the greatest tag value for further processing.

Patentansprüche

1. Dekodiermethode zur Verwendung in einem Etikettabtastsystem des Typs, bei dem eine Vielzahl von Mehrzeichenetikettkandidaten als Ergebnis mehrerer Abstastungen eines Etiketts erzeugt werden kann, wobei ein Satz, der biz zu drei Indikatoren (N1, N2, D') enthalten kann, für jedes Zeichensegment in jedem Etikettkandidat abgeleitet und gespeichert wird und zwei (N1, N2) der genannten drei indikatoren fähig sind, entweder einzelne Zeichen oder Zeichen-Teilsätze zu identifizieren und der genannte dritte Indikator (D') fähig ist, ein einzelnes Zeichen innerhalb eines gegebenen Teilsatzes zu identifizieren, weiter dadurch gekennzeichnet, dass sie folgende Schritte aufweist:

a) Vergleich der ersten zwei Indikatoren (N1, N2) für jedes Zeichensegment in einem gegebenen Kandidaten mit den entsprechenden Indikatoren auf ein entsprechendes Zeichensegment in zumindest einem anderen Etikettkandidaten um zu erkennen, ob die Etikettkandidaten Übereinstimmende Zeichen oder Übereinstimmende Zeichen-Teilsätze aufweisen;

b) Speichern der dritten Indikatoren (D') im Hinblick auf entsprechende Zeichensegmente bis alle Etikettkandidaten verglichen wurden, und

c) Wahl eines Einzelzeichens für jedes Zeichensegment, das als von einem Teilsatz besetzt im Verhältnis zu den gespeicherten dritten Indikatorwerten für des Segment identifiziert wurde.

2. Dekodiermethode nach Anspruch 1, dadurch gekennzeichnet, dass das zu dekodierende Etikett

aus einer Vielzahl von Strichmarkierungs-Zeichensegmenten besteht, wobei jedes Segment davon eine gleiche Anzahl von Strichen und Zwischenräumen aufweist und die genannten ersten und zweiten Indikatoren durch Bildung von Verhältnissen zwischen den kombinierten Breiten der aufeinanderfolgenden Strich-Zwischenraumpaare und der Gesamtbreite der Zeichensegmente abgeleitet werden.

3. Dekodiermethode nach Anspruch 2, dadurch gekennzeichnet, dass der genannte dritte Indikator als Funktion der kombinierten Strichbreiten in einem Zeichensegment und der Grössen der ersten und zweiten Indikatoren abgeleitet wird.

4. Dekodiermethode nach Anspruch 3, dadurch gekennzeichnet, dass der genannte erste Indikator N1 und der genannte zweite Indikator aus folgenden Gleichungen abgeleitet werden:

$$N1=\frac{7T1}{TR} \qquad N2=\frac{7T2}{TR}$$

in denen:

T1 die kombinierte Breite des ersten Strich-Zwischenraum-Paars im Zeichensegment ist,

T2 die kombinierte Breite des ersten Strich-Zwischenraum-Paars im Zeichensegment und

T3 die kombinierte Breite der beiden Striche und Zwischenräume, aus denen das Zeichensegment besteht.

5. Dekodiermethode nach Anspruch 4, dadurch gekennzeichnet, dass Einzelzeichen oder Zeichen-Teilsätze je nach den abgeleiteten Werten N1 und N2 als gerade oder ungerade klassiert werden und dass der dritte indikator wie folgt bestimmt wird:

$$\frac{2NB}{1+N1+N2}$$

als ungerades Zeichen

$$\frac{2(7-NB)}{1+(7-N1)+N2}$$

als gerades Zeichen

wo NB die gesamte Strichbreite des Zeichensegments bedeutet.

6. Dekodiermethode nach Anspruch 5, dadurch gekennzeichnet, dass dem dritten Indikator ein absoluter Wert D' mit einem Vorzeichen zugeteilt wird, wenn dieser Indikatorwert gleich oder grösser als ein gegebener Schwellenwert ist während derselbe absolute Wert D' mit umgekehrtem Vorzeichen dem dritten Indikator zugeteilt wird, wenn dieser Indikatorwert kleiner als der gegebenene Schwellenwert ist.

7. Dekodiermethode nach Anspruch 6, dadurch gekennzeichnet, dass der dritte Indikator gespeichert wird, indem die algebraischen Werte D' mit einem positiven Ergebnis summiert werden, das einem von zwei möglichen Zeichen in einem Teilsatz entspricht, und mit einem negativen Ergebnis, das dem anderen der zwei möglichen Zeichen entspricht.

8. Dekodiermethode nach den Ansprüche 1 bis 7, dadurch gekennzeichnet, dass sie ausserdem noch zusätzliche Schritte aufweist, d.h. das Speichern eines Hinweissymbolwertes für jeden Etikettkandidaten, der der Anzahl der Dekodierungen des Kandidaten entspricht, und Auswähl des Etikettkandidaten mit dem grössten Hinweissymbolwert für weitere Verarbeitung.

Revendications

1. Procédé de décodage utilisable dans un système de balayage d'étiquettes du type dans lequel une pluralité d'étiquettes multicaractères (dites "candidates" ci-après) représentant différentes interprétations possibles d'une même étiquette peuvent être engendrées consécutivement à de multiples balayages de cette dernière, procédé dans lequel un ensemble de trois indicateurs ou moins (N1, N2, ΣD') est obtenu et stocké pour chaque segment de caractère dans chaque candidate, deux (N1, N2) desdits trois indicateurs étant capables d'identifier soit des caractères individuels soit des sous-ensembles de caractères, ledit troisième indicateur (ΣD') étant capable d'identifier un caractère donné dans uns sous-ensemble donné, ledit procédé étant caractérisé en outre en ce qu'il comprend les étapes suivantes consistant à:

a) comparer les deux premiers indicateurs (N1, N2) pour chaque segment de caractère dans une candidate donnée avec les indicateurs correspondants pour un segment de caractère correspondant dans au moins une autre candidate afin de déterminer si les candidates possèdent des caractères ou des sous-ensembles de caractères identiques;

b) accumuler les troisièmes indicateurs (ΣD') pour des segments de caractères correspondants jusqu'à ce que toutes les candidates aient été comparées; et

c) choisir un caractère particulier pour chaque segment de caractère identifié comme étant occupé par un sous-ensemble en fonction des valeurs des troisièmes indicateurs accumulés pour ce segment.

2. Procédé de décodage selon la revendication 1 caractérisé en ce que l'étiquette à décoder se compose d'une pluralité de segments de caractères codés au moyen de barres, chaque segment comportant un même nombre de barres et d'espaces, et en ce que lesdits premier et second indicateurs sont obtenus en déterminant les rapports des largeurs combinées de paires barre-espace successives à la largeur totale du segment de caractère.

3. Procédé de décodage selon la revendication 2 caractérisé en ce que ledit troisième indicateur est déterminé en fonction des largeurs combinées des barres d'un segment de caractère et des valeurs des premier et second indicateurs.

4. Procédé de décodage selon la revendication

3 caractérisé en ce que ledit premier indicateur N1 et ledit second indicateur sont déterminés au moyen des équations suivantes:

$$N1=\frac{7T1}{TR} \qquad N2=\frac{7T2}{TR}$$

où

T1 est la largeur combinée de la première paire barre-espace dans le segment de caractère,

T2 est la largeur combinée de la première paire espace-barre dans le segment de caractère, et

TR est la largeur combinée des deux barres et espaces qui constituent le segment de caractère.

5. Procédé de décodage selon la revendication 4 caractérisé en ce que les caractères individuels ou les sous-ensembles de caractères sont classés comme caractères impairs ou pairs en fonction des valeurs N1 et N2 obtenues, et en ce que le troisième indicateur est établi comme suit:

$$\frac{2NB}{1+N1+N2}$$

pour les caractères impairs ou

$$\frac{2(7-NB)}{1+(7-N1)+N2}$$

pour les caractères pairs

où NB est la largeur totale des barres du segment de caractère.

6. Procédé de décodage selon la revendication 5 caractérisé en ce qu'une valeur absolue D' pourvue d'un premier signe algébrique est affectée au troisième indicateur lorsque la valeur de ce dernier est égale ou supérieure à une valeur de seuil donnée tandis que la même valeur absolue D' de signe algébrique opposé est affectée au troisième indicateur lorsque la valeur de celui-ci est inférieure à la valeur de seuil donnée.

7. Procédé de décodage selon la revendication 6 caractérisé en ce que le troisième indicateur est accumulé en effectuant la somme des valeurs algébriques D', un résultat positif représentant l'un de deux caractères possibles dans un sous-ensemble et un résultat négatif représentant l'autre des deux caractères possibles.

8. Procédé de décodage selon l'une quelconque des revendications 1 à 7 caractérisé en ce qu'il inclut des étapes supplémentaires consistant à stocker une valeur d'étiquette pour chaque candidate, valeur représentant le nombre de décodages dont cette candidate a fait l'objet, et à sélectionner la candidate possédant la valeur d'étiquette la plus élevée aux fins d'un traitement complémentaire.

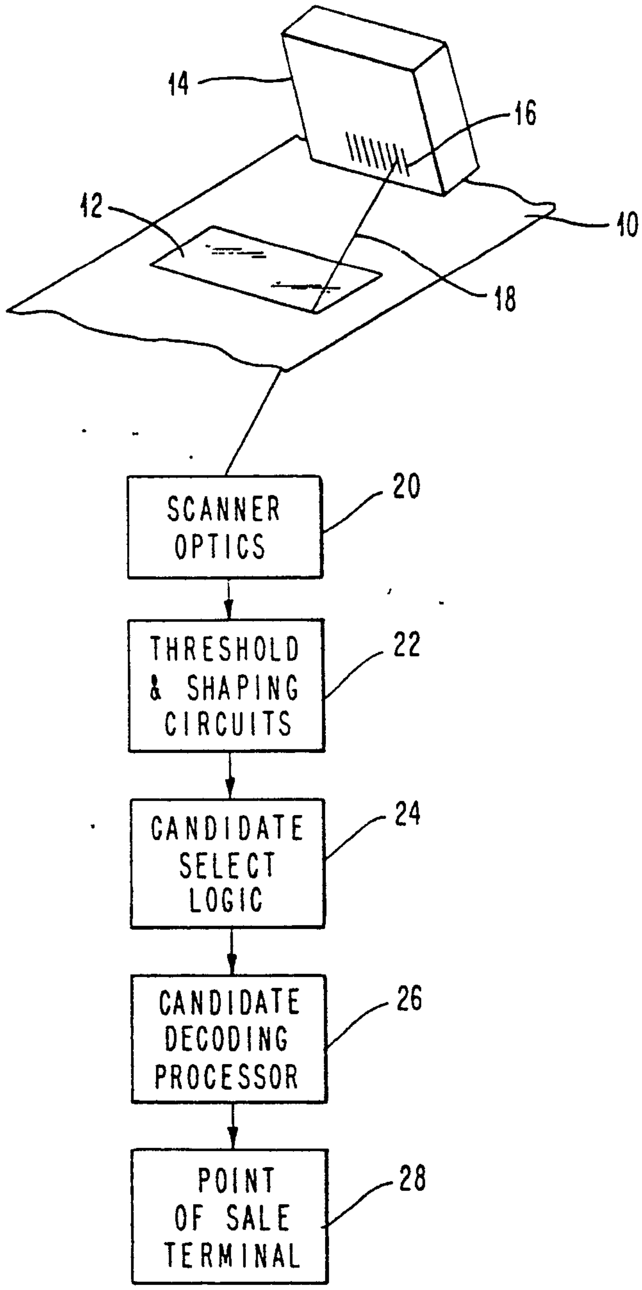

14
16
12
10
18
SCANNER OPTICS
20
THRESHOLD & SHAPING CIRCUITS
22
CANDIDATE SELECT LOGIC
24
CANDIDATE DECODING PROCESSOR
26
POINT OF SALE TERMINAL
28

FIG. 1

FIG. 2

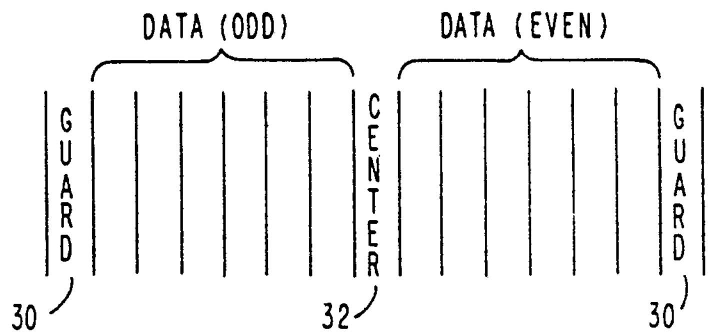


FIG. 3

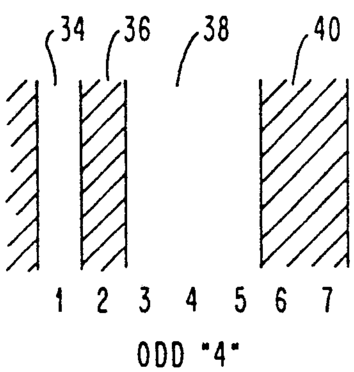


FIG. 5

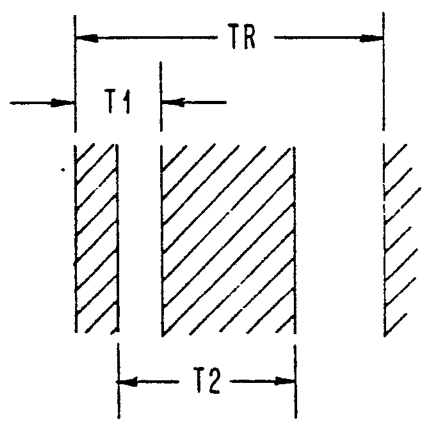


FIG. 4

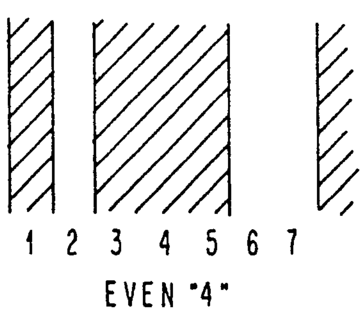
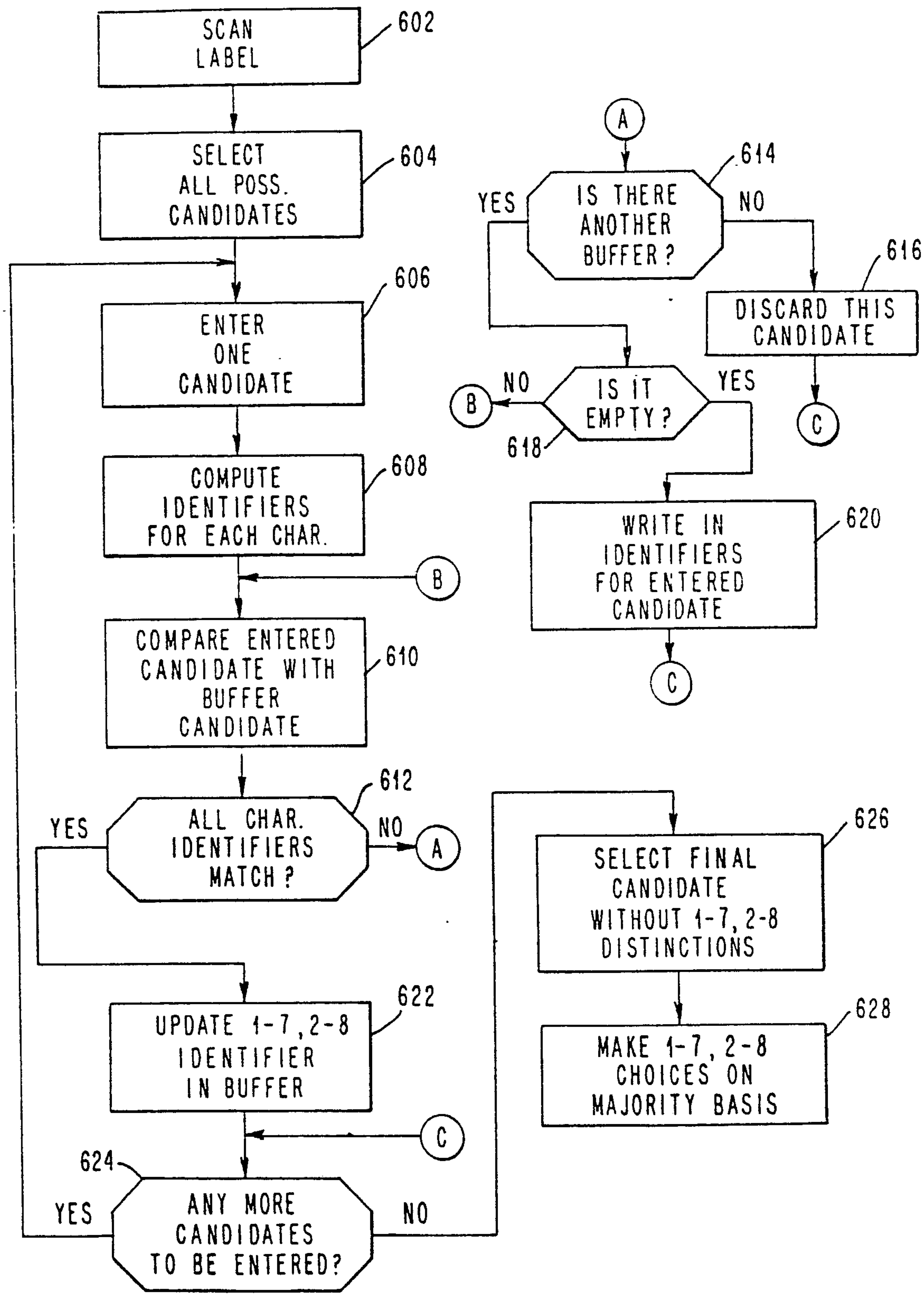


FIG. 6


SCAN LABEL
602
SELECT ALL POSS. CANDIDATES
604
ENTER ONE CANDIDATE
606
COMPUTE IDENTIFIERS FOR EACH CHAR.
608
B
COMPARE ENTERED CANDIDATE WITH BUFFER CANDIDATE
610
ALL CHAR. IDENTIFIERS MATCH ?
612
YES
NO
A
UPDATE 1-7, 2-8 IDENTIFIER IN BUFFER
622
C
624
ANY MORE CANDIDATES TO BE ENTERED?
YES
NO
A
IS THERE ANOTHER BUFFER ?
614
YES
NO
DISCARD THIS CANDIDATE
616
C
IS IT EMPTY ?
618
NO
B
YES
WRITE IN IDENTIFIERS FOR ENTERED CANDIDATE
620
C
SELECT FINAL CANDIDATE WITHOUT 1-7, 2-8 DISTINCTIONS
626
MAKE 1-7, 2-8 CHOICES ON MAJORITY BASIS
628

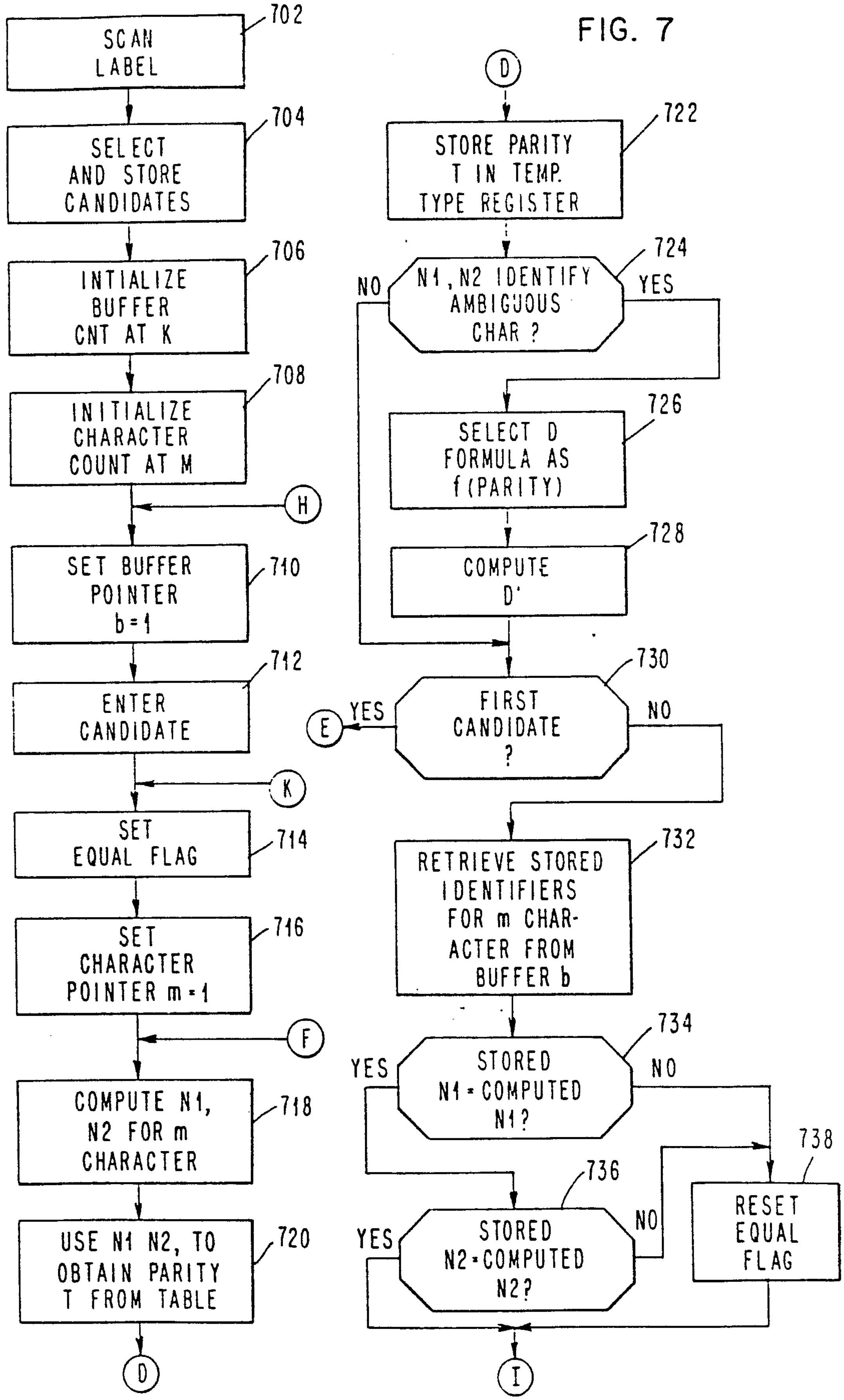

SCAN LABEL
702
SELECT AND STORE CANDIDATES
704
INTIALIZE BUFFER CNT AT K
706
INITIALIZE CHARACTER COUNT AT M
708
H
SET BUFFER POINTER b=1
710
ENTER CANDIDATE
712
K
SET EQUAL FLAG
714
SET CHARACTER POINTER m=1
716
F
COMPUTE N1, N2 FOR m CHARACTER
718
USE N1 N2, TO OBTAIN PARITY T FROM TABLE
720
D
D
STORE PARITY T IN TEMP. TYPE REGISTER
722
N1, N2 IDENTIFY AMBIGUOUS CHAR ?
724
NO
YES
SELECT D FORMULA AS f(PARITY)
726
COMPUTE D'
728
FIRST CANDIDATE ?
730
YES
NO
E
RETRIEVE STORED IDENTIFIERS FOR m CHARACTER FROM BUFFER b
732
STORED N1=COMPUTED N1?
734
STORED N2=COMPUTED N2?
736
RESET EQUAL FLAG
738
I

FIG. 7

FIG. 8

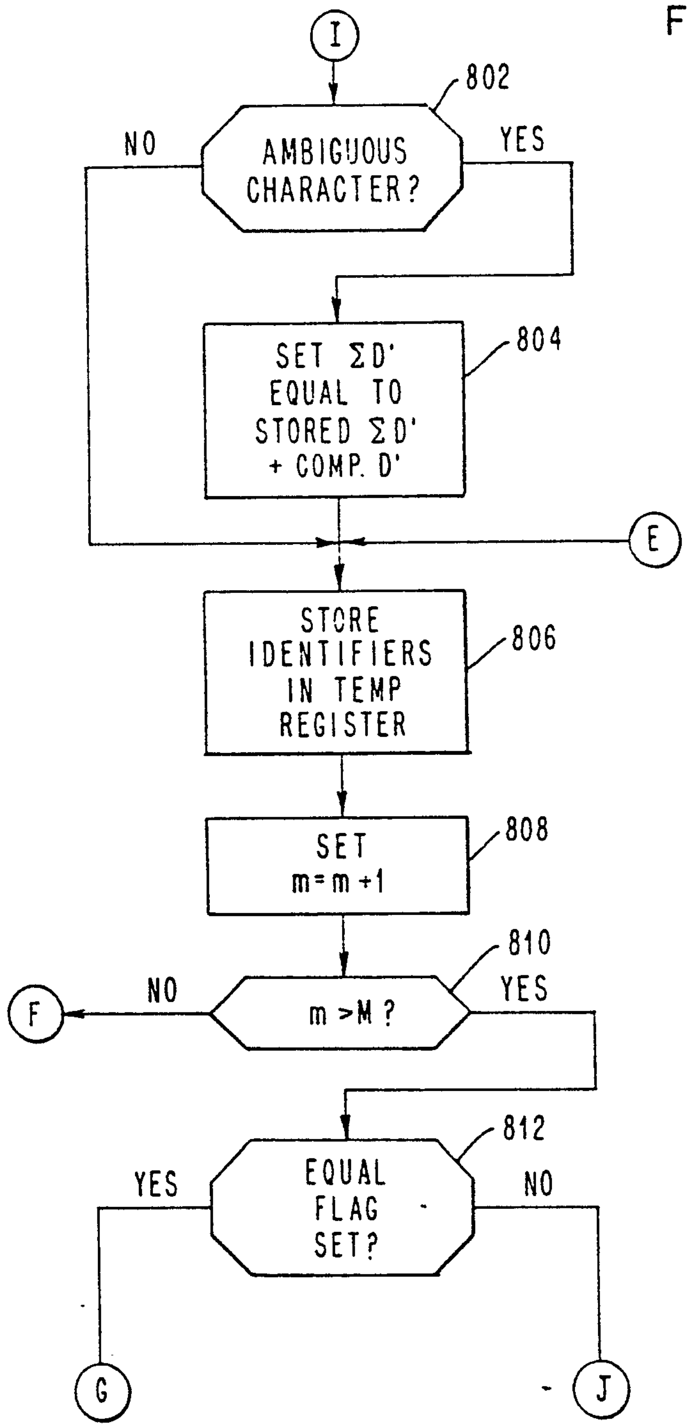

I
802
AMBIGUOUS CHARACTER?
NO
YES
SET ΣD' EQUAL TO STORED ΣD' + COMP. D'
804
E
STORE IDENTIFIERS IN TEMP REGISTER
806
SET m=m+1
808
810
m >M ?
NO
YES
F
812
EQUAL FLAG SET?
YES
NO
G
J

FIG. 9

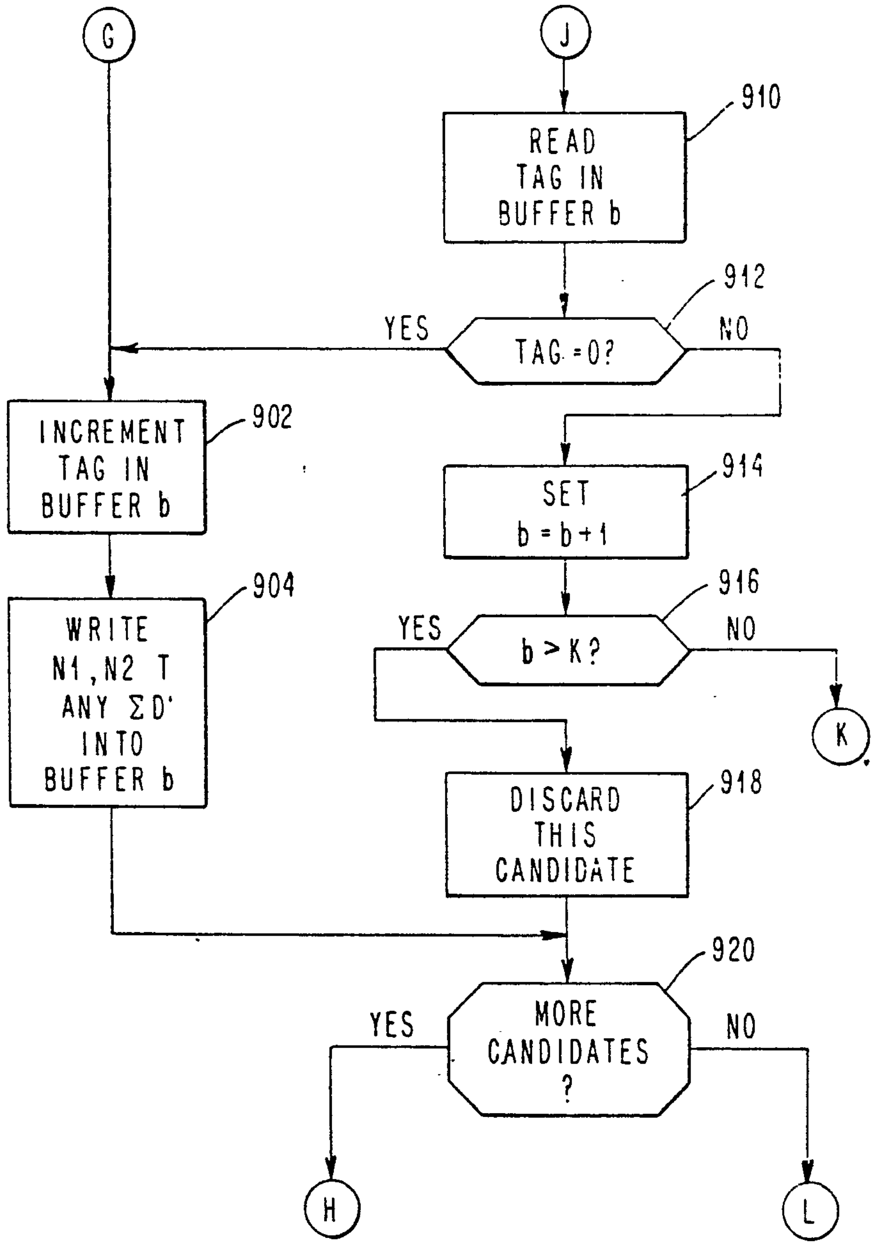
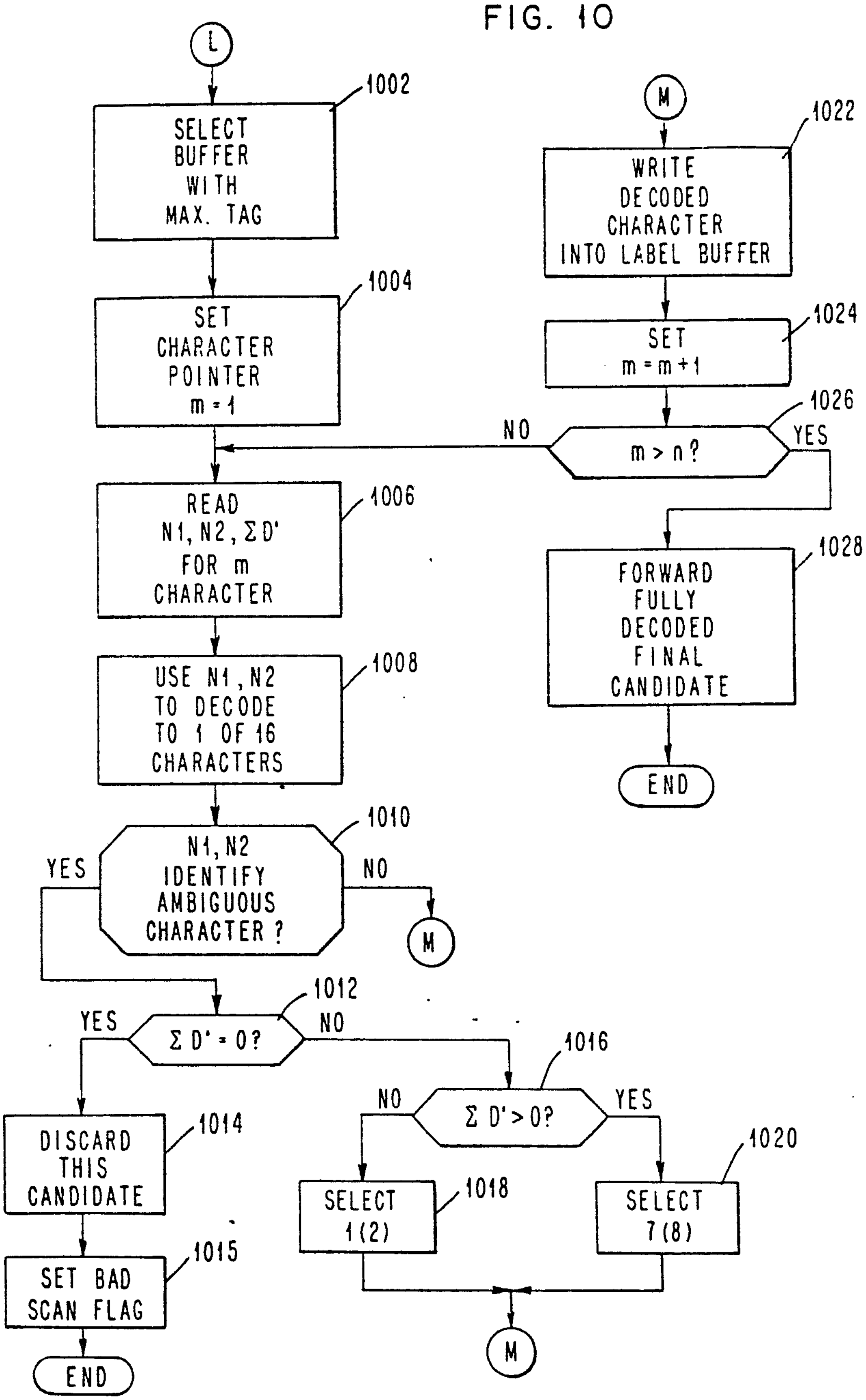

G
J
READ TAG IN BUFFER b
910
TAG =0?
912
YES
NO
INCREMENT TAG IN BUFFER b
902
SET b = b+1
914
WRITE N1, N2 T ANY ΣD' INTO BUFFER b
904
b > K?
916
YES
NO
K
DISCARD THIS CANDIDATE
918
MORE CANDIDATES ?
920
YES
NO
H
L

FIG. 10


L
1002
SELECT BUFFER WITH MAX. TAG
1004
SET CHARACTER POINTER m = 1
1006
READ N1, N2, ΣD' FOR m CHARACTER
1008
USE N1, N2 TO DECODE TO 1 OF 16 CHARACTERS
1010
N1, N2 IDENTIFY AMBIGUOUS CHARACTER ?
YES
NO
M
1012
ΣD' = 0?
YES
NO
1014
DISCARD THIS CANDIDATE
1015
SET BAD SCAN FLAG
END
1016
ΣD' > 0?
NO
YES
1018
SELECT 1(2)
1020
SELECT 7(8)
M
M
1022
WRITE DECODED CHARACTER INTO LABEL BUFFER
1024
SET m = m + 1
1026
m > n ?
NO
YES
1028
FORWARD FULLY DECODED FINAL CANDIDATE
END